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Original article

No improvement in the post-TKA infection prognosis when the implant is not reimplanted: Retrospective multicentre study of 72 cases

T. Amouyel[a], B. Brunschweiler[a], B. Freychet[b], C. Lautridou[c], P. Rosset[b], P. Massin[d,e,*], and the French Hip and Knee Society (SFHG)[f]

[a] Service de chirurgie orthopédique et traumatologique, CHU Amiens, 1, place Victor-Pauchet, 80054 Amiens, France
[b] Service d'orthopédie 2, hôpital Trousseau, CHU, 37044 Tours cedex 1, France
[c] Service d'Orthopédie, Hôpital Raymond-Poincaré, AP–HP, 104, boulevard Raymond-Poincaré, 92380 Garches, France
[d] Service de Chirurgie Orthopédique, Hôpitaux Universitaires Paris Nord Val de Seine, Site Bichat, 46, rue Henri-Huchard, 75877 Paris cedex 18, France
[e] EA REMES, Université Paris Diderot, Sorbonne Paris Cité, 75010 Paris, France
[f] French Hip and Knee Society, 56, rue Boissonade, 75014 Paris, France

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ABSTRACT

Introduction: For the surgeon and patient, permanent removal of an infected knee prosthesis is an unwelcome decision taken out of necessity because unfavourable local or general conditions may increase the likelihood of mechanical or infectious failure upon prosthesis reimplantation. The purpose of this study was to determine if permanent removal of an infected total knee arthroplasty (TKA) implant controls the infection and prevents above-the-knee amputation when reimplantation turns out to be too risky. It was hypothesized that removal without reimplantation contributes to eradicating the infection and helps to avoid amputation.

Patients and methods: Seventy-two consecutive patients who underwent TKA removal between 2000 and 2010 at 14 hospitals were reviewed. The TKA removal was followed by knee fusion in 29 cases or implantation of a permanent cement spacer in 43 cases.

Results: If failure is defined as clinically obvious recurrence of the infection, the survival rate was $65 \pm 5\%$ at 2 years; 44% of patients had a recurrence of the infection, 8% had undergone amputation and 19% presented with nonunion at the last follow-up. The male gender and the presence of multiple co-morbidities were predisposing factors for failure.

Discussion: Control of the infection is not guaranteed upon TKA implant removal; the success rate is lower than in cases of two-stage reimplantation. The outcomes in this study are worse than those of other published studies. This is likely due to the heterogeneity in the patient population and treatments, along with the presence of co-morbidities. This treatment option should be the last recourse before amputation.

Level of evidence: Level IV, Retrospective cohort study.

1. Introduction

The management of periprosthetic joint infection after total knee arthroplasty (TKA) is a complex problem, even when following the recommendations made by scientific societies [1,2]. The cost associated with surgical revision of an infected knee is high [3,4] and the number of TKA cases performed throughout the world is steadily increasing [5]. Although the criteria and methods for reimplantation after TKA removal have been fairly well standardized, the indications for permanent removal and knee fusion are more subjective [6]. Above-the-knee amputation is the final course of action in certain cases [7]. Permanent removal is a failure for the surgeon and patient. In most cases, this solution is imposed upon them by unfavourable local and general conditions making the probability of successful reimplantation very low due to mechanical or infectious failure.

To define the outcomes of the removal of infected TKA without reimplantation, a multicentre retrospective study was undertaken

* Corresponding author. Service de Chirurgie Orthopédique, Hôpitaux Universitaires Paris Nord Val de Seine, Site Bichat, 46, rue Henri-Huchard, 75877 Paris cedex 18, France.
E-mail address: phmassin@gmail.com (P. Massin).

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Table 1
Demographics for the study cohort and the excluded.

	Study cohort $n=72$	Excluded cohort $n=37$	P value
Mean age (years)	68	71	0.21
Gender (male)	27	18	0.42
Mean BMI	29.1	29.8	0.67
No co-morbidities	29	12	0.41
Obesity	25	15	0.67
Intramedullary extension stem	45	21	0.42
No previous septic procedure	40	20	0.44

BMI: body mass index.

in 14 referral centres. Multidisciplinary teams included infectious disease specialists who prescribed the antibiotic treatment protocols. Some of these TKA removal procedures were followed by immediate or secondary knee fusion, while other cases were managed by implanting a static or articulated cement spacer.

We hypothesized that removal without reimplantation contributes to eradicating the infection and helps to avoid amputation. We sought to answer two questions:

- What is the eradication rate as a function of the treatment used: knee fusion or cement spacer?
- Are there any predisposing factors?

2. Material and methods

The files of 109 consecutive patients with a periprosthetic knee infection treated by permanent implant removal between 2000 and 2010 were reviewed retrospectively. In some cases, the decision to not reimplant was made immediately because of precarious local or general conditions, such as lack of skin coverage, extensor mechanism deficiency, or life-threatening intraoperative haemodynamic instability. In other cases it was made secondarily after implantation of a cement spacer that was initially intended to be temporary, but became permanent out of necessity.

Thirty-seven patients were excluded because less than 24 months of follow-up after the TKA removal was available (9 had died, 25 were lost to follow-up, 3 had undergone immediate amputation), which made it impossible to confirm healing. Exclusion of these 37 patients did not alter the demographics of the initial patient population (Table 1). Patients with less than 24 months follow-up but who had a recurrence of the infection were included.

TKA removal was the first procedure carried out in 40 of the 72 remaining patients. Eleven of the other patients had already undergone TKA revision and seven had undergone two or more revision procedures. Twelve patients had undergone joint lavage and synovectomy and two had undergone this combination multiple times. The infection was caused by a single bacterial species in 83% of cases. The most common micro-organisms were methicillin-susceptible *Staphylococcus aureus* and coagulase-negative staphylococci (Table 2).

The TKA removals were followed by implantation of a cement spacer in 43 cases and knee fusion in 29 cases, with 7 of these being fixed with a nail, 7 by an external fixator and 1 with a plate. The 14 remaining cases of knee fusion were fixed with a modular intramedullary (IM) nail; with this nail, there is a persistent space between fragments but a cement spacer was not added to prevent shortening. A comparison of the fused knees and those implanted with a cement spacer is given in Table 3.

The fusion was deemed "planned" when it was planned before the explantation and performed right away ($n=13$) (Fig. 1). The fusion was deemed "forced" ($n=16$) when it was required secondarily after a cement spacer had been implanted and the infection controlled because reimplantation seemed too risky due to precarious skin coverage or extensor mechanism deficiency. In the 43 remaining cases, neither fusion nor prosthesis reimplantation was carried out. Implantation of a cement spacer corresponded to the first stage of a protocol providing for delayed reimplantation. The spacer could either be static or articulated (Fig. 1). The second stage (reimplantation) was not performed, either because the local conditions were too precarious or because patients with good tolerance of the spacer who had previously undergone multiple surgeries refused the reimplantation procedure.

Once biopsy samples had been collected, appropriate intravenous dual antibiotic coverage was administered for 15 days; this was followed by oral antibiotic therapy generally combining rifampicin with quinolones for staphylococci infections and amoxicilin for streptococci infections. This course of curative antibiotics was extended until the biological parameters normalised (minimum of 45 days).

Failure of the procedure was defined as clinical recurrence of the infection (persistent drainage that may or may not be purulent) requiring a revision procedure (new removal of the fusion or

Table 2
Micro-organisms identified in the collected samples.

	%	n
Staphylococci (69%)		
MSSA	36.7	44
MRSA	12.5	15
CoNS	20	24
GNB (12%)		
Enterobacteria	10	12
Pseudomonas aeruginosa	2.5	3
Streptococci	5.8	7
Enterococci	5	6
Corynebacteria	1.7	2
Anaerobes	3.3	4
Others	2.5	3
Total	100	120

MSSA: methicillin-susceptible *Staphylococcus aureus*; MRSA: methicillin-resistant *Staphylococcus aureus*; CoNS: coagulase-negative staphylococci; GNB: Gram-negative bacilli.

Table 3
Demographics of the patients who underwent knee fusion and those who received a cement spacer.

	Fusion $n=29$	Spacer $n=43$	P value
Age (mean ± SD)	64 ± 12	69 ± 10	0.06
BMI (mean ± SD)	29.5 ± 6.4	29.6 ± 7.4	0.78
Gender (male)	11	16	1.00
No co-morbidities	13	14	0.33
BMI > 30	9	16	0.62
No extension stem	10	17	0.66
Number of previous surgeries	4 ± 2	3 ± 2	0.22
Number of septic surgeries	2 ± 1	2 ± 1	0.42

BMI: body mass index.

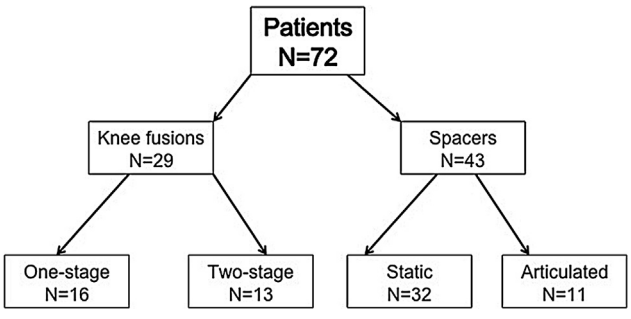

Fig. 1. Flow chart summarizing the number and types of procedures done.

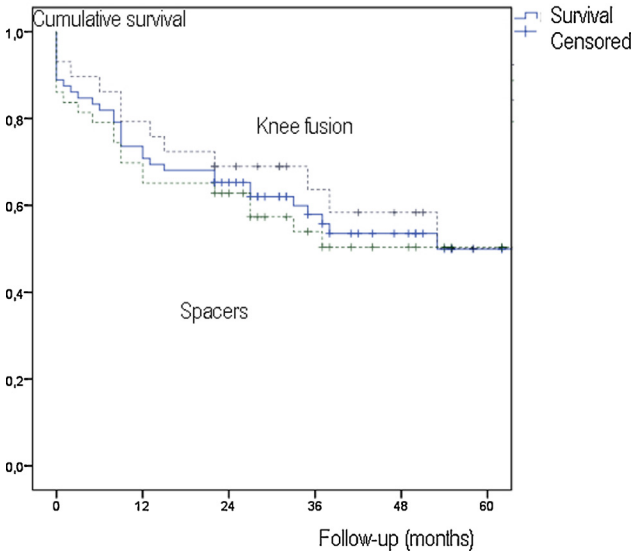

Fig. 2. Kaplan-Meier survival curves. From top to bottom: survival of fusion cases (dashed line), overall survival (continuous line), survival of spacer cases (dashed line).

spacer, lavage or amputation) or conservative treatment (suppressive antibiotic therapy) that led to persistence of a more or less productive fistula. Early death due to septic shock was considered as an infectious failure.

Patient data were captured and made anonymous with database software (4D® v12.3 SAS, Clichy, France). Data were analysed statistically using SPSS software (Version 20.0, SPSS IBM, New York, USA). The Shapiro-Wilk test was used to verify if the quantitative variables were normally distributed. Student's *t*-test was used to compare mean values for normally distributed, continuous variables (age, bone mass index [BMI], number of previous procedures). The BMI data had a log-normal distribution and underwent logarithmic transformation before the *t*-test. The Chi^2 test was used to test hypotheses with qualitative variables (sex ratio, co-morbidity, procedure, intramedullary stems). If the expected frequency was less than 5, the Fisher's exact test was performed (number of previous procedures). Kaplan-Meier survival curves were constructed for the entire cohort, the spacer group and the fusion group, and then compared with the Logrank test. The significance threshold was set at $P < 0.05$. Single-tail monovariate analysis was used to test two potential risk factors: body mass index (BMI) and presence/absence of co-morbidities.

3. Results

At 2 years, the survival rate without clinically obvious recurrence of the infection was 65 ± 5% (Fig. 2). It was 50 ± 7% after 5 years. The mean time to infection recurrence was 13 months (0–79). In the 24 months after the surgery, 32 patients (44%) had a recurrence of the infection (Fig. 3). Microbiological testing revealed the same causative micro-organism in 19 cases and a different one in 2 cases. No micro-organism could be identified in the other 11 cases, despite clinical recurrence of the infection.

The 2-year survival rate was 69% ± 9% for patients who underwent knee fusion and 62% ± 7% for those who had a spacer implanted ($P = 0.54$). Planned fusion procedures resulted in a 38% failure rate and forced fusion procedures in a 46% failure rate ($P = 0.9$). Implantation of a static spacer resulted in a 63% failure rate and that of an articulated spacer in a 39% failure rate ($P = 0.15$). At the last follow-up, 14 of the arthrodesis procedures had not resulted

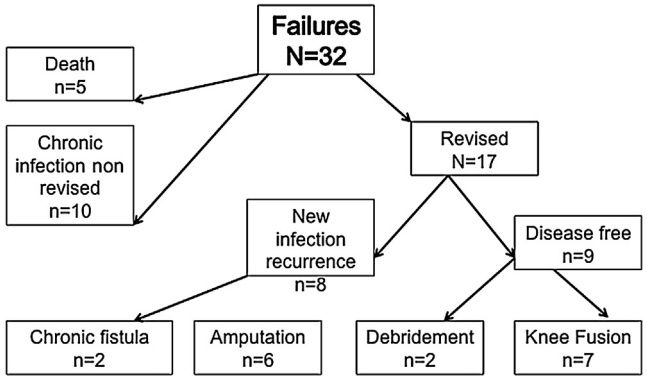

Fig. 3. Outcomes of the failure cases.

in fusion (one with a modular IM nail) and two still had an active infection.

After treatment of these recurrent infections, 23 cases were labelled as permanent failures (32%). Among the 19 spacer failures, 7 patients were not revised and were left with chronic fistulation, 3 died of septic shock and 9 had their infection resolved at the last follow-up through either secondary fusion (7 cases) or lavage (2 cases). Among the 13 cases of failed fusion, 2 patients died of septic shock, 3 were left with chronic fistulation and 8 underwent surgical revision (6 above-the-knee amputations and 2 persistent chronic fistulas after lavage).

The male gender and presence of co-morbidities were the only factors significantly associated with infection recurrence (Table 4).

4. Discussion

Permanent removal of an infected TKA implant does not guarantee the infection will be resolved, as it was eradicated in only 56% of cases in this study. This eradication rate is lower than the one for two-stage prosthetic revision reported by Haleem et al. [8] (91%), Kubista et al. [9] (84.2%) and in the Romano et al. [10]

Table 4
Comparison of successful outcomes (no recurrence of clinical infection) and failures.

	Successful $n = 40$	Failure $n = 32$	*P* value
Age (mean ± SD)	69 ± 11	66 ± 13	0.62
BMI (mean ± SD)	28.6 ± 6.3	30.4 ± 7.8	0.29
Number of previous surgeries	3 ± 2	4 ± 2	0.80
Number of previous septic surgeries	2 ± 1	2 ± 1	0.13
Gender (men/women)	9/31	18/14	0.007*
No co-morbidities	19	8	0.04*
One or two stems present	27	18	0.33
Obesity (BMI > 30)	12	13	0.45
Fusion/spacer	17/23	12/20	0.667
Skin condition			
1 or 2 wounds	32	25	0.84
2+ wounds or fistula	8	7	
Procedure(s) carried out before TKA removal			
None	20	20	0.56
Lavage	9	5	
Revision	11	7	
Number of procedures carried out before TKA removal			
None	20	20	0.54
1	14	9	
2 or more	6	3	

BMI: body mass index.
* Significant difference.

(89.8%) meta-analysis. Not re-implanting the TKA did not prevent amputation: it was performed after 6 cases of failed knee fusion (8.3%).

For knee fusions, the results are even more paradoxical when compared to certain highly optimistic studies with eradication rate reported by Mabry et al. [11] of 92% for knee fusions accomplished with an intramedullary locked nail and 80–100% for fusions performed with two external fixators [12,13]. For Wu et al. [14], fusion led to a higher eradication rate than changing the TKA in cases of failure after the first reimplantation. Patients who underwent knee fusion had better functional scores than those who underwent a second TKA revision [14]. According to Schwarzkopf et al. [15], fusion by nail (81.5%) or with plates (77.8%) resulted in eradication of the infection and bone union, while other techniques resulted in failure. The inferior results with external fixators have been attributed to the poor local conditions in patients who have often undergone multiple surgeries [15–17], which contradicts the Parratte et al. finding of 100% eradication [13].

The fusion rate after arthrodesis in the current study was also lower than that reported in published studies. This can be explained by the appreciable number of arthrodesis procedures undertaken because of the patient's poor general condition, lack of skin coverage or significant and unplanned bone defects. When it is performed in the context of a planned procedure (i.e. immediately), the results seem better. Incavo et al. [18] looked at 21 cases of IM nail fixation of the arthrodesis and found that fusion was obtained in 17 cases, with a time to fusion of 7 months. At the last follow-up, all of the joints had fused after several procedures, which confirms the results of Crockarell et al. [19] who reported 100% fusion rate in 15 patients who underwent IM nail arthrodesis. Leroux et al. [20] reported a 94% fusion rate in 17 patients who underwent anterograde monoblock nail arthrodesis with only 1 failure.

Another reason for the low fusion rate could be related to the surgical technique; 14 patients in this study were operated with a modular IM nail where fusion is not the immediate goal because this type of construct provides immediate and long-lasting stability that makes weight bearing possible. But in all, there was only one case of nonunion in this subgroup of modular IM nail treatment and only one case of infectious failure. The fusion rate reported in published studies is high: McQueen et al. [21] obtained a 92% fusion rate by compressing the bone sections against each other. Senior et al. [22] obtained the same results in 14 patients who underwent two-stage arthrodesis with a modular IM nail. Other studies [12,23–25] have reported functional outcomes with the modular nail without opposing the bone segments – hence without bone union – that were similar to those of other arthrodesis procedures where the goal is immediate fusion.

We found no significant differences between the survival after TKA infection for the patients that underwent fusion and those given spacers. The temporary spacer can become permanent based on the surgeon's decision or because of circumstances imposed upon him (operability, patient refusal, etc.). This has mainly been described in cases of periprosthetic joint infection at the shoulder [26] and ankle [27]. In the knee, the spacer's long-term strength is uncertain. Choi et al. [28] followed seven patients who underwent this procedure and found only one mechanical spacer failure; the other patients had satisfactory functional scores and infection control after up to 6 years of follow-up.

The presence of co-morbidities is a well-known predisposing factor for infectious failure. Fistulas, symptom duration of greater than 8 days [29], advanced age, immunosuppression and the number of previous procedures are known risk factors [30], although we did not find them to play a role in this study. The increased risk in male patients was also found in the study by Koh et al. [31] and the meta-analysis by O'Connor [32]. Methicillin-resistant bacteria and the lack of micro-organisms identified in culture also contributed to failure [33] but were not found in this study.

This work has the typical limitations of retrospective, observational studies, especially in complex and varied clinical situations. The multicentre nature of this study resulted in heterogeneous techniques being used, thereby generating a centre effect that can bias the results interpretation. In many cases, the surgeon had no choice to perform knee fusion or not reimplant the prosthesis because the patient had precarious local or general conditions due to multiple previous surgeries. This can explain the poor outcomes from a mechanical and biological point of view.

5. Conclusion

TKA removal without reimplantation in cases of chronic periprosthetic knee infection can be either a deliberate course of action or one that the surgeon has no other choice but to make. This study has demonstrated that infection control is far from being achieved; the 56% success rate was lower that the eradication rate following reimplantation. A cement spacer seems to be well tolerated in the medium term and its use does not increase the rate of infection recurrence relative to knee fusion.

Disclosure of interest

Philippe Massin is a consultant for Evolutis, Zimmer and Synthes and has received royalties from Ceramconcept and Microport.

The other authors declare that they have no conflicts of interest concerning this article.

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